Fine Scale Baleen Whale Behavior Observed Via Tagging Over Daily Time Scales

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LONG-TERM GOALS

Tagging studies of cetaceans have focused primarily on two disparate time scales: short (hours) or long (weeks to months). Studies using sensor-rich suction-cup tags, focal follows, and proximate environmental sampling provide highly detailed observations of behavior that can be interpreted in the context of conspecific behavior, oceanographic conditions and prey distribution; however, tag attachment durations are typically short (hours) and sustained tracking and environmental sampling from small vessels is logistically challenging. Longer-term tagging studies using implanted satellite tags can provide location data over periods of weeks to months; however, inferences about behavior at time scales of hours to days are difficult to make with the limited sensor data returned by the tags and the low rate at which location data are provided (typically only 1-2 locations per day). While studies at both short and long time scales are enormously beneficial, there is also a critical need to understand cetacean behavior at intermediate daily time scales. Recent efforts to assess the impacts of sound on marine mammals and to estimate foraging efficiency have called for the need to measure daily activity budgets to quantify how much of each day an individual devotes to foraging, resting, traveling, or socializing. Moreover, many conservation issues require an understanding of daily diving activity (e.g., how much time each day does an individual spend near the bottom, at depth, in a sound channel, or at the surface?). Finally, several studies have observed diel trends in calling behavior or prey distribution that suggest diel variability in cetacean behavior; hypotheses about diel patterns in behavior can only be addressed definitively with tagging studies over daily time scales.

My long-term goal is to develop a tagging and tracking system that will allow cetaceans to be followed over time scales of days from an oceanographic vessel so that environmental sampling can be conducted in proximity to the tagged whale. Analyses of diving and movement behavior from the tagging and tracking data could then be combined with observations of oceanographic conditions and prey distribution to elucidate the environmental factors that influence both behavior and distribution over daily time scales.

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OBJECTIVES

My objectives are (1) to develop a reliable tagging and tracking system that allows sustained unambiguous tracking over time scales of days, and (2) to characterize the relationship between diel variability in the foraging behavior of baleen whales (North Atlantic right whales and sei whales) and the diel vertical migration behavior of their copepod prey. I hypothesize that (1) right whales track the diel vertical migration of copepods by feeding near the bottom during the day and at the surface at night, and (2) sei whales are unable to feed on copepods at depth during the day, and are therefore restricted to feeding on copepods at the surface only. Because copepod diel vertical migration is variable over time (days to weeks) and space (tens of kilometers) (Baumgartner et al. 2011), I further hypothesize that sei whales range much further than right whales to find areas where copepods are exhibiting weak diel vertical migration behavior.

APPROACH

Most tracking studies rely on radio or acoustic transmitters incorporated in the animal-borne tag to provide a homing signal. Radio waves do not penetrate seawater, so opportunities to locate an animal carrying a radio transmitter are limited to very short periods when the animal is at the surface and the tag is exposed to air. Acoustic transmitters allow continuous tracking while an animal is submerged, but the reception range of a high-frequency transmitter (~30 kHz) is limited to 1-2 kilometers at most. While both of these tracking methods provide bearing from the tracking vessel to a tagged animal, neither provides accurate range measurements, so location estimation is ambiguous. In practice, these methods rely strongly on establishing visual contact with the tagged animal to verify its true location. Because visual contact requires daylight, these methods are far less effective during the night. Moreover, tracking via a homing signal is labor intensive and exhaustive, and is therefore difficult to maintain with great accuracy for tens of hours.

To accomplish sustained tracking over daily time scales, two innovations are required: (1) a reliable tag attachment that lasts for more than one day, and (2) an unambiguous tracking capability that does not rely on visual contact. For studies of baleen whale ecology, we have developed a dermal attachment that is implanted into the skin and blubber of a whale and acts as a short-term anchor for carrying tags for periods of hours to days (Baumgartner and Hammar 2010, Baumgartner et al. submitted). We are combining this new attachment with a commercially available archival tag (MK10-PATF; Wildlife Computers) to allow real-time tracking via a FastLoc GPS receiver and an ARGOS radio transmitter integrated in the whale-borne tag. Every 5-15 minutes, FastLoc GPS data collected during the tagged whales' surfacings will be telemetered from the tag to a local ARGOS receiver aboard an oceanographic vessel where the whales' position will be calculated and displayed to allow both daytime and nighttime tracking (Figure 1). This precise tracking ability will allow the ship to continuously remain in proximity to the whale so that it can collect both behavioral, oceanographic, and prey observations.

WORK COMPLETED

The project has only just begun, so I am in the initial phases of tag attachment design and software and equipment procurement. I have discussed the tracking system specifications with Dr. Ed Bryant (Wildtrack Telemetry Systems, Ltd.) who has developed beta software to acquire ARGOS transmissions via a radio receiver, decode the ARGOS message (including embedded Fastloc GPS data), collect GPS ephemeris data from an integrated GPS receiver, calculate a tag position using the

Fastloc and GPS ephemeris data, and finally display the position and the ship's position on the computer monitor. Dr. Bryant has supplied this software as well as a hardware list required to support the system. I am in the process of procuring these hardware components. I have also placed an order with Wildlife Computers for 2 MK10-PATF tags for use in the project as well as a dummy tag to facilitate the tag attachment design process. Lead time for receipt of the tags is 10-12 weeks.

I have also begun the process of designing the tag attachment with WHOI mechanical engineer Mr. Terry Hammar. As mentioned above, the tag attachment will rely on a dermal anchor previously developed by Mr. Hammar and me. We plan to incorporate a spring mechanism and a small cage to house the MK10-PATF so that the tag sits snugly against the whale's skin after deployment. I feel this is absolutely essential (1) to minimize any irritation the tag would cause by rubbing on the whale's skin, and (2) to ensure reliable and consistent exposure of the tag to the sky to facilitate GPS signal reception and ARGOS transmission upon each surfacing. The tag will be attached to the cage via a corrosive tether so that the tag can detach at a specified time. The tag will subsequently be recovered to access the high-resolution depth data, and the anchor and cage will be shed from the whale within days. Finally, we will be developing a tag deployment system that relies on either a pole or a compressed air launcher.

I have been in touch with Dr. Peter Corkeron of the NEFSC about participating in their spring 2013 cruise to the Great South Channel in the southwestern Gulf of Maine to tag right and sei whales. Dr. Corkeron is enthusiastic about our project, and has invited us to be a part of the cruise. We are conducting preliminary cruise planning now.

RESULTS

No engineering or scientific results are available at this time.

IMPACT/APPLICATIONS

This work will directly help efforts to mitigate the effects of anthropogenic activities on baleen whales by characterizing (1) daily acitivty budgets, (2) where in the water column whales feed both day and night, and (3) the relationship between physical processes, prey distribution, and whale behavior. Ultimately, our ability to predict or even forecast whale distribution will hinge on a fundamental understanding of foraging behavior and how that behavior varies with changes in prey behavior and distribution.

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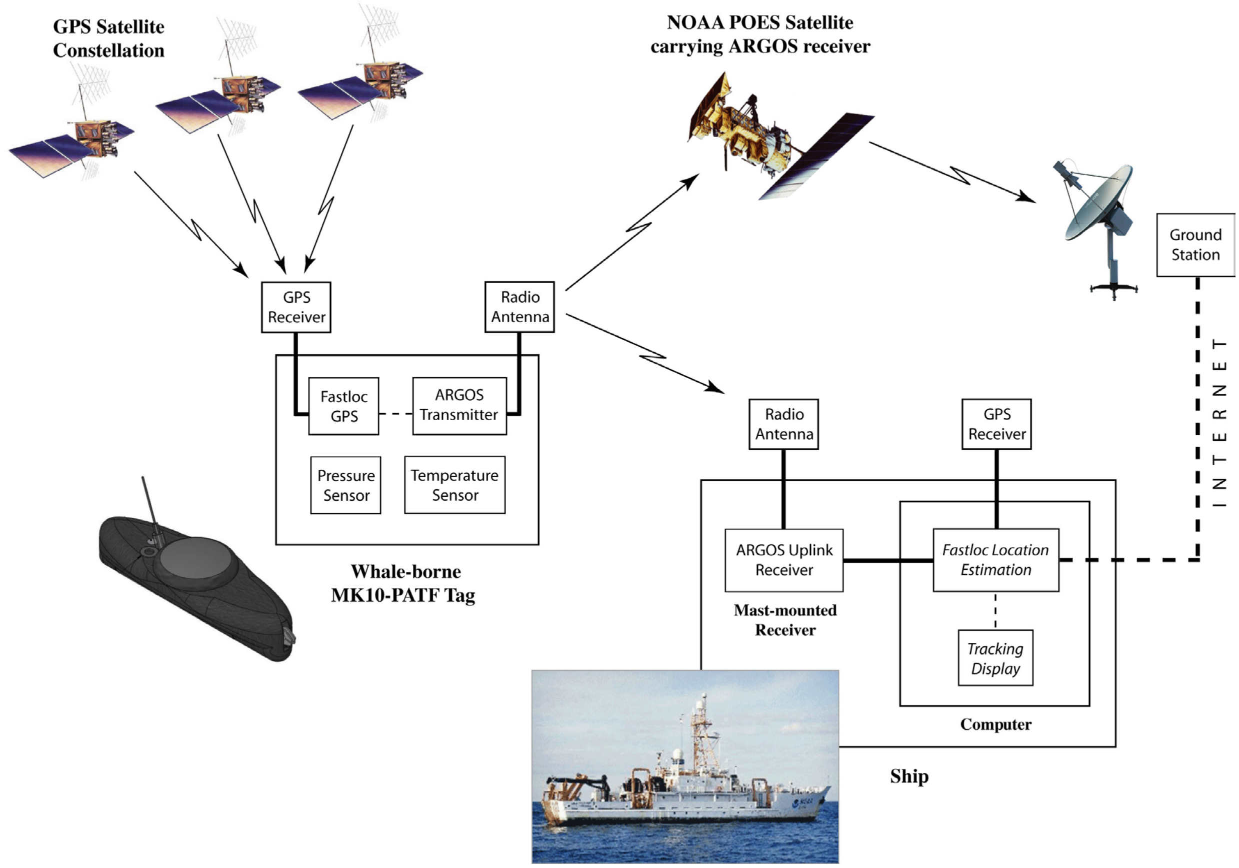

Figure 1. Block diagram of tracking system based on whale-borne Wildlife Computers MK10-PATF tag and shipboard ARGOS receiving system. Fastloc GPS data is telemetered via an ARGOS transmitter from the tag to a local receiver mounted on a nearby ship's mast. The location of the tag is computed from the received Fastloc data and GPS satellite ephemeris data collected with a ship-mounted GPS receiver. In the unlikely event that the ARGOS transmissions from the tag cannot be received locally, Fastloc data from the tag can be acquired through the ARGOS system and relayed via the ship's Internet connection. All location data will be displayed on a chart on the ship's bridge to facilitate tracking.